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Integrated Cognitive-neuroscience Architectures for Understanding Sensemaking (ICArUS):

Phase 1 Challenge Problem Walkthrough

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1 Introduction

This document provides a broadly accessible overview of the Integrated Cognitive-neuroscience Architectures for Understanding Sensemaking (ICArUS) Phase 1 challenge problem. The pages include screen shots (denoted by black rectangles) from the ICArUS Phase 1 Test and Evaluation (T&E) Graphical User Interface (GUI), including the tutorial that participants viewed before and during experiments.

This document is not meant to stand alone. For a detailed description of the ICArUS Phase 1 challenge problem, please refer to the following document:

> Burns, K., Greenwald, H., & Fine, M. (2014). *ICArUS Phase 1 Challenge Problem Design and Test Specification*. MITRE Technical Report, MTR140410.

More information about materials developed for Phase 1 T&E is available in the following document:

> Burns, K., Fine, M., Bonaceto, C., & Oertel, C. (2014). *Integrated Cognitive-neuroscience Architectures for Understanding Sensemaking (ICArUS): Overview of Test and Evaluation Materials*. MITRE Technical Report, MTR140409.

These documents are available at: http://www.mitre.org/publications.

For reference purposes, Table 2 from the Phase 1 Challenge Problem Design and Test Specification is reproduced below. This table outlines the 6 tasks (also known as "missions") that comprise the primary Phase 1 challenge problem. An additional Task 7, outlined in Section 9 below, is described in Appendix A of the Phase 1 Challenge Problem Design and Test Specification.

In general, tasks of the Phase 1 challenge problem require predicting which of several enemy groups is most likely to attack a given location, or which of several locations a group will most likely attack. Tasks 1-3 require statistical learning, as evidence is accumulated over time from reports of individual attacks. Tasks 4-6 require integrating various layers of intelligence, as evidence about a single attack is provided by multiple independent sources coincident in time. Task 7 combines aspects of earlier tasks while introducing a notion of self-initiated sensemaking.

All materials used in human experiments were approved by MITRE's Institutional Review Board prior to use.

Task	Description
1	**Learning two groups**. [10 blocks of 10 trials]. Attacks by two groups (A, B) are generated (SIGACTS), one on each trial, by two normal distributions – each with a different base rate, center location, and dispersion. On the last trial of each block the subject is shown an attack location and asked to predict the probability of attack by each group, {A%, B%}. The subject then makes a forced choice (A or B), to allocate resources against the attack. At the end of the trial the subject sees ground truth (A or B) at the attack location and he reports surprise (on a 7-point Likert scale).
2	**Learning four groups**. [5 blocks of 20 trials]. Unlike Task 1, there are four different groups (A, B, C, and D). Also, before reporting {A%, B%, C%, D%}, the subject is required to draw four circles – each representing the "two-to-one boundary" for a group (i.e., attack by the group is twice as likely inside the circle compared to outside the circle). After reporting the probabilities {A%, B%, C%, D%} and making a forced choice in allocating resources against one group, the subject is shown ground truth (A, B, C, or D) at the attack location and he reports surprise.
3	**Finding centers**. [5 blocks of 20 trials]. Unlike Task 2, the task is to find group centers along roads "as the cow walks" (rather than "as the crow flies"). After each block of trials, the subject clicks four points A, B, C, and D on the roads – each representing the "center of gravity" for a group (i.e., maximum likelihood location for a group's center, given the group's attacks). The subject then reports {A%, B%, C%, D%} at the attack location. After reporting the probabilities and making a forced choice in allocating resources, the subject is shown ground truth (A, B, C, or D) at the attack location and he reports surprise.
4	**Scoping attacks**. [10 trials, 2 stages per trial]. Unlike Task 3, the subject is given the center (from HUMINT) for one group, along with four possible locations 1, 2, 3, and 4 of attack by that group. In stage 1, the subject is required to estimate the probability of attack at each location based on a normal distance decay function along roads. In stage 2, the subject is given the regional boundaries for groups (SOCINT), along with the inside/outside region attack likelihoods from PROBS. The subject is required to aggregate the prior (HUMINT) and SOCINT probabilities. The subject allocates resources in percentages (not a forced choice) across the sites, and is shown ground truth (1, 2, 3, or 4). The subject reports surprise after observing ground truth.
5	**Fusing layers**. [10 trials, 4 stages per trial]. Unlike Task 4, the subject is given an attack location (SIGACT) along with group centers (HUMINT) for four groups (A, B, C, D). The subject is also given the probabilities of attack by each group {A%, B%, C%, D%}, based on the HUMINT distance function. The subject is then given four more INTS (IMINT, MOVINT, SIGINT, SOCINT), one at a time, along with the likelihoods (from PROBS) for features of INTS. At each stage the subject updates probabilities {A%, B%, C%, D%}. After the last stage the subject allocates resources in percentages {A%, B%, C%, D%} against the groups. At the end of the trial the subject is shown ground truth and he reports surprise.
6	**Choosing layers**. [10 trials, 3 stages per trial]. Much like Task 5, except the subject decides which layer of INT (IMINT, MOVINT, SIGINT, or SOCINT) to receive on each of three stages, after receiving the initial HUMINT. The criterion for each choice is to maximize the expected amount of useful information to be gained from the choice of an INT.

Purpose

You will be playing the role of a geospatial intelligence analyst over the course of seven missions.

In each mission, you must **make judgments concerning the attacks by enemy groups**. There are 2-4 enemy groups that are active in the area of interest at any given time. They are known as Aqua, **Bromine**, Citrine, and Diamond, or A, **B**, C, and D for short.

Your task is to **make sense** of various intelligence sources in order **to predict which group** is most likely to attack or **which location** a group will attack. An important aspect of your decision making will be **to assess the relative chance, or probability**, of attack by all groups in the area.

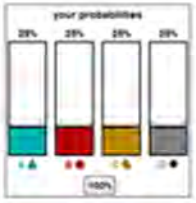
For example, if there are four groups then you will need to **report the probability of attack** by each group: A, **B**, C, D.

Entering probabilities

You will enter probabilities using the interface shown below. There are 3 methods of entering probabilities; you may choose any combination of methods you like.

1. You can use the mouse to drag each slider up or down.
2. You can "click" within a slider to automatically move it to that point.
3. You can use the scroll wheel on your mouse to make fine adjustments within a slider.

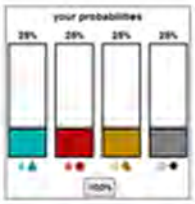
Please try each method now.



Next/Back

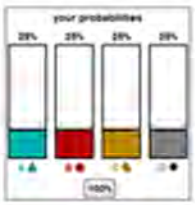
Your responses should reflect **how strongly** you believe each group is likely to attack, **rounded to the nearest percent**. Your response probabilities must sum to 100%. You can do this in your head, or you can let the system sum for you. If your answers do not sum to 100%, clicking "Next" will automatically adjust the probabilities to 100% (the adjustment will maintain the relative proportion across all answers). For instance:

Please click "Next" to try it now.



Next/Back

You may click "Back" if you wish to make any adjustments. When satisfied, click "Next" to report these levels as your final judgments. Please note that once you have clicked "Next" a second time, you may not go back to change your answers.



Scoring for Judging the Probabilities of Attack

Each mission will consist of 10 – 20 instances or **trials** in which you provide judgments of attacks.

At the end of each mission, you will be scored on how well you judged probabilities. Your judgments will be compared to the calculations of an optimal analyst that has the same information as you. This score will be averaged over multiple attacks, and will only be given at the end of a Mission. For example:

- Assume your probability judgments for an attack are:
  {A = 40%, B = 30%, C = 20%, D = 10%}

and the optimal analyst's judgments are:
{A = 10%, B = 20%, C = 30%, D = 40%}.

Using a similarity-based scoring system, your score for just this attack would be 63 of 100 points.

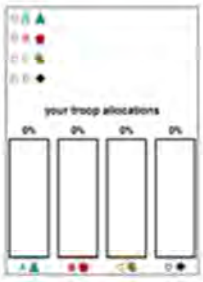
- If your probability estimates exactly matched the optimal analyst, then your score would be 100 of 100 points.

Allocating Troops

After reporting probabilities of each attack, you will be asked to **allocate troops** against a group or to a location. You will receive a score based on the correctness of your troop allocation choices.

In Missions 1 - 3, you will be asked to choose a **single** group or location to allocate all your troops to.

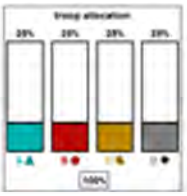
Try allocating troops against a single group now using the interface below (select a radio button).



Allocating Troops

In Missions 4 - 7, you will be asked to allocate troops in percentages. You can allocate 100% to one group, or you can allocate some percentage to each group as long as the percentages sum to 100%. You will enter your choices using an interface like the one you used to enter probabilities of attacks.

Try allocating troops against several groups using the interface below.



Scoring for Troop Allocation

After entering your responses, you will be shown which group attacked, and will receive a score. The score is based on the **percentage or proportion** of troops you allocate. For example:

- Assume you allocate troops against a single group (Missions 1 - 3)
  {A = 100%, B = 0%}

  If the attack was by group A, you would score 100 out of 100 points in allocating troops.

  If the attack was instead by group B, you would score 0 points.

- Assume you allocate troops in percentages (Mission 4 – 7)
  {A = 40%, B = 30%, C = 20%, D = 10%}.

  If the attack was by group A, you would score 40 out of 100 points in allocating troops.

  If the attack was instead by group B, you would score 30 points.

Surprise

At certain points in the mission, you will be asked to **report your degree of surprise** about an observation, by selecting from a scale of 7 options ranging from "Not At All Surprised" to "Extremely Surprised".

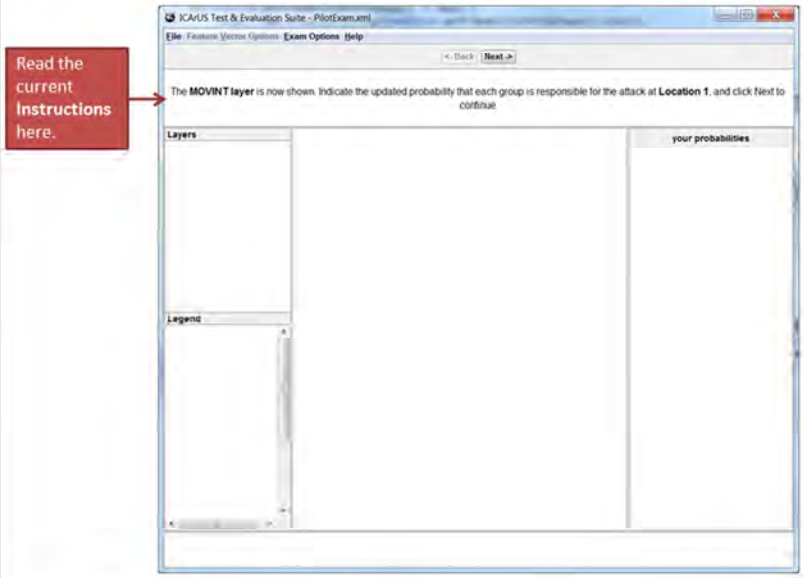
Note that, unlike probability judgments and troop allocations, there are **no right or wrong answers** when it comes to surprise. Please report whatever degree of surprise you feel at the moment you are prompted.

Screen Display

This is an overview of the interface you will be using to receive information and make judgments. The screen is divided into several areas.

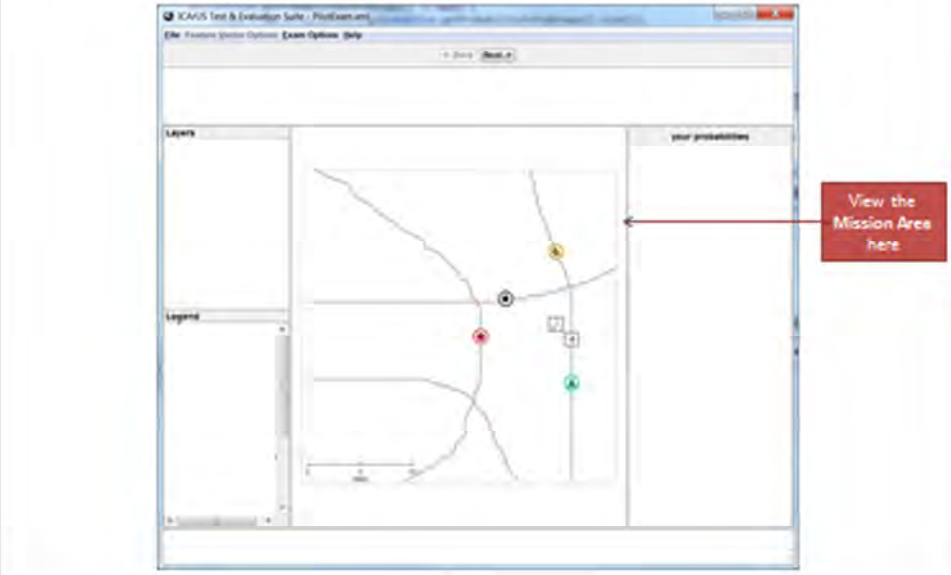
Screen Display

At each step of each mission, you will be given current instructions of what to do next at the top of the screen.



Screen Display

You can see what the current situation is in the Mission Area

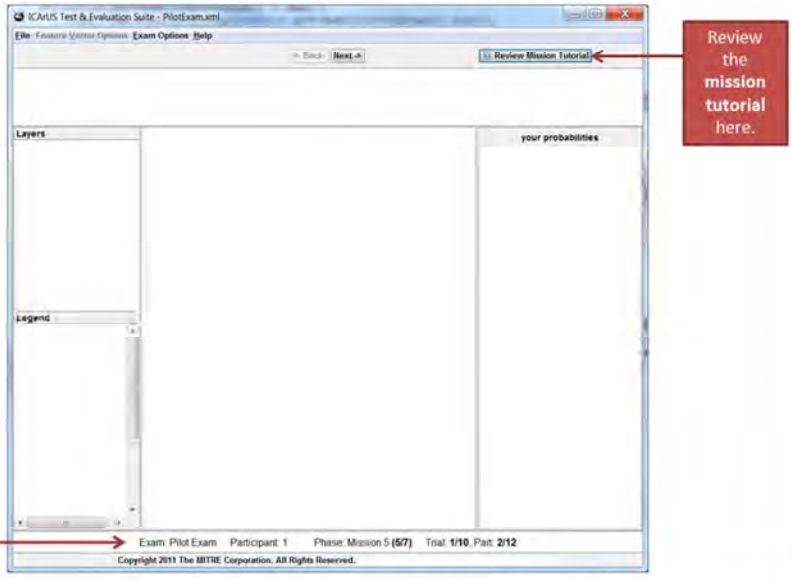


Screen Display

All of your attack probability judgments, troop allocations, and surprise responses will be given on the right hand side of the screen.

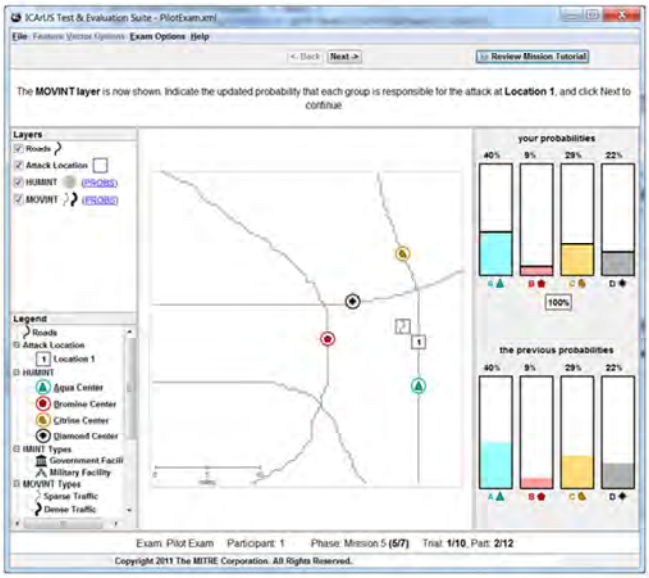
Screen Display

You can click a button to review the mission tutorial at any time.
You can see the current mission status at the bottom of the screen.



Screen Display

This is a complete example of the display you will see for a typical mission.
There's no need to study it now, since you will become more familiar with it later.



Missions

During the experiment you will be asked to complete 7 different missions. More specific instructions will be given at the start of each mission.

You will be given a break after Mission 3, then another break after Mission 5. You are free to take more breaks, but please try to wait until the end of a mission.

Please ask the study proctor if you need help at any time during the experiment.

IMPORTANT: Please **do not use** a pen, pencil, paper, calculator, or any other external device. The study is intended to measure how well you can perform without any aids.

Click Next to begin Mission 1.

2 Mission 1

Learning two groups. [10 blocks of 10 trials]. Attacks by two groups (A, B) are generated (SIGACTS), one on each trial, by two normal distributions – each with a different base rate, center location, and dispersion. On the last trial of each block the subject is shown an attack location and asked to predict the probability of attack by each group, {A%, B%}. The subject then makes a forced choice (A or B), to allocate resources against the attack. At the end of the trial the subject sees ground truth (A or B) at the attack location and he reports surprise (on a 7-point Likert scale).

Mission 1: Attacks by Two Groups

You will see attacks at various locations in the mission area. One attack will be shown each time you click 'Next'. Each attack is caused by group A▲ or B⬟, as indicated on the screen.

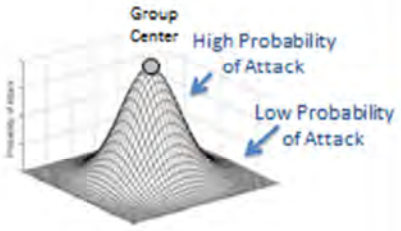
On every 10th attack you will be provided an attack location, but not the identity of the attacking group (A or B). Your job is to judge the probability that the attack is by group A or B.

You will do this 10 times as 100 attacks are accumulated on the screen.

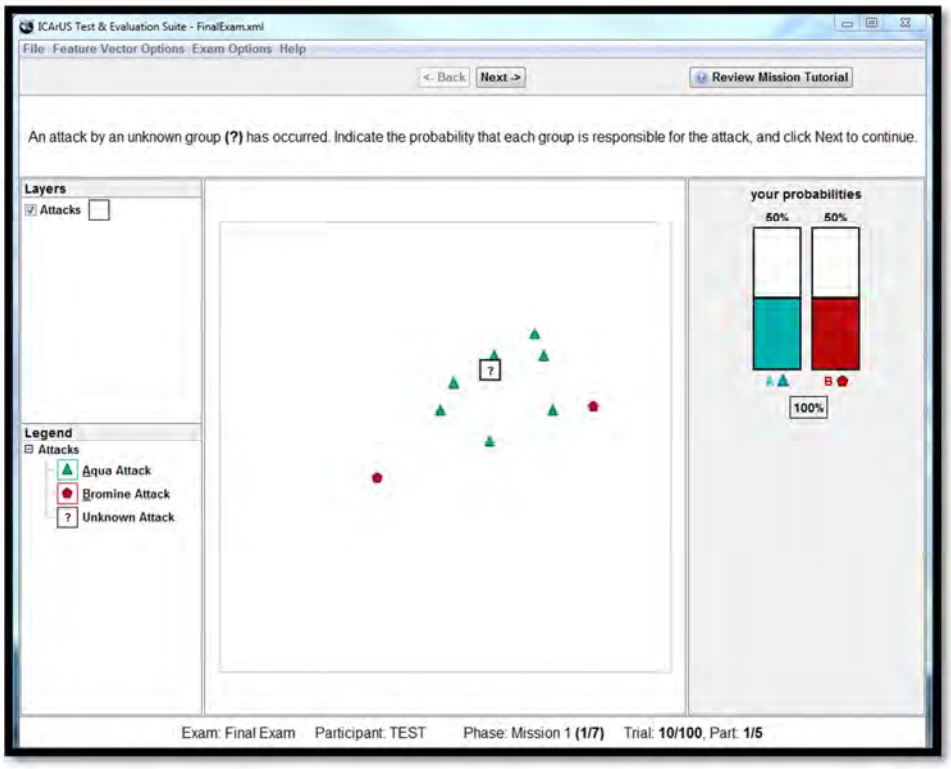
Mission 1: Group Tendencies

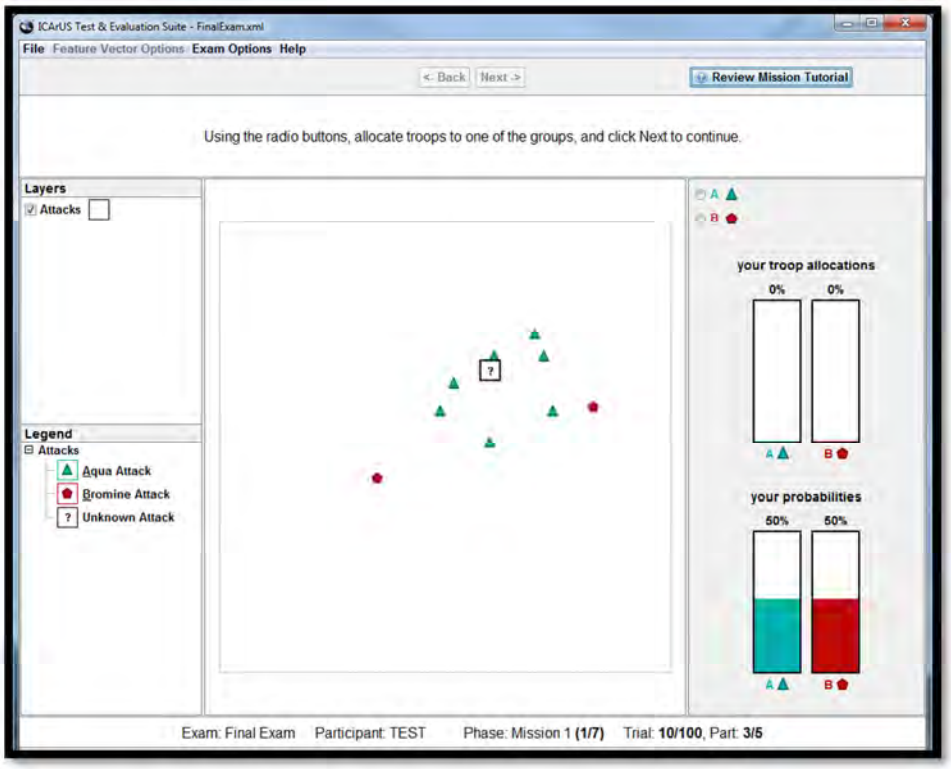
At the start of the Mission, you will not know anything about a group's attack tendency. By studying the pattern of attacks, you will gradually become able to judge the probability of attack by each group. Each group will behave differently. For example:

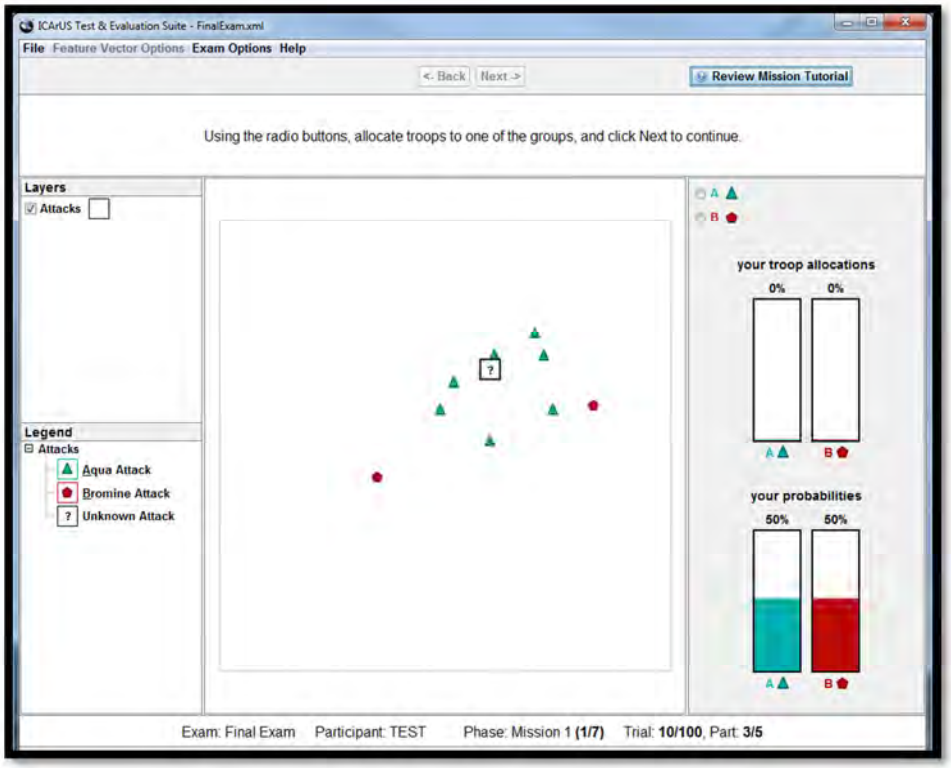
- Each group has a different operational **center** that remains constant throughout Mission 1. The probability of attack is highest near the center, and decreases farther from the center along a bell curve (see illustration). Note: the group center will not be visible; it must be inferred from the pattern of attacks.

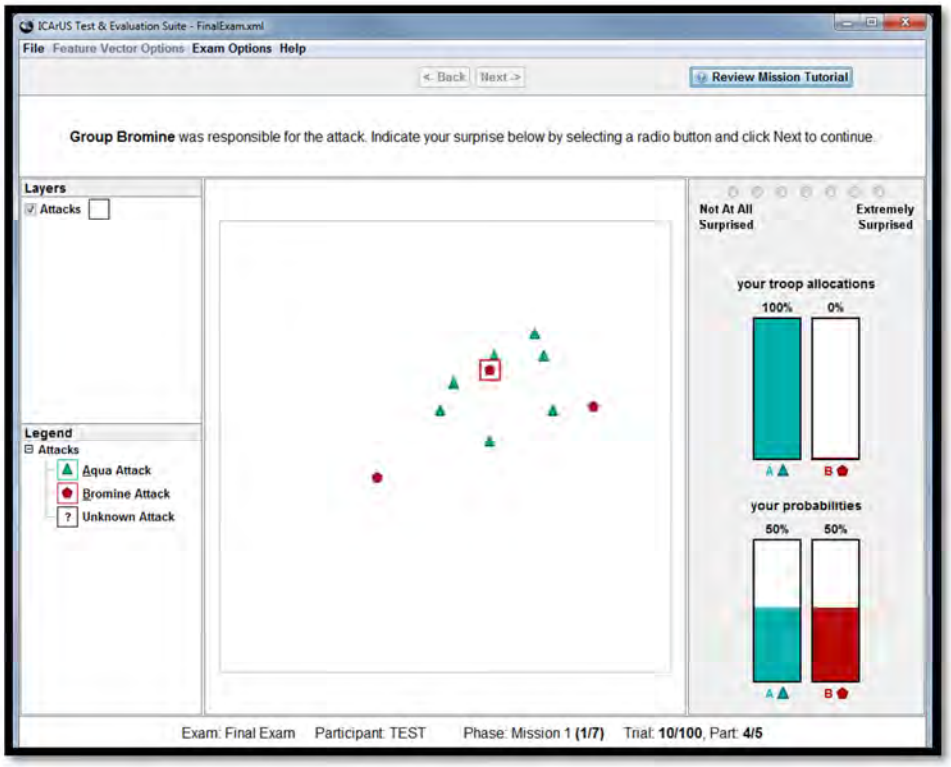


- One group may attack farther from its group center than another (**spread** out more).
- One group may attack more **frequently** than another.
- You should always judge based on **all** the attacks you have seen, **not just the most recent attacks**.


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back
Next ->
Review Mission Tutorial
An attack by an unknown group (?) has occurred. Indicate the probability that each group is responsible for the attack, and click Next to continue.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Unknown Attack
your probabilities
50%
50%
A
B
100%
Exam: Final Exam Participant: TEST Phase: Mission 1 (1/7) Trial: 10/100, Part: 1/5


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back
Next ->
Review Mission Tutorial
Using the radio buttons, allocate troops to one of the groups, and click Next to continue.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Unknown Attack
your troop allocations
0%
0%
your probabilities
50%
50%
Exam: Final Exam Participant: TEST Phase: Mission 1 (1/7) Trial: 10/100, Part: 3/5


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
Using the radio buttons, allocate troops to one of the groups, and click Next to continue.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Unknown Attack
your troop allocations
0%
0%
your probabilities
50%
50%
Exam: Final Exam Participant: TEST Phase: Mission 1 (1/7) Trial: 10/100, Part: 3/5


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
Group Bromine was responsible for the attack. Indicate your surprise below by selecting a radio button and click Next to continue.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Unknown Attack
Not At All Surprised
Extremely Surprised
your troop allocations
100%
0%
your probabilities
50%
50%
Exam: Final Exam Participant: TEST Phase: Mission 1 (1/7) Trial: 10/100, Part: 4/5

3 Mission 2

Learning four groups. [5 blocks of 20 trials]. Unlike Task 1, there are four different groups (A, B, C, and D). Also, before reporting {A%, B%, C%, D%}, the subject is required to draw four circles – each representing the "two-to-one boundary" for a group (i.e., attack by the group is twice as likely inside the circle compared to outside the circle). After reporting the probabilities {A%, B%, C%, D%} and making a forced choice in allocating resources against one group, the subject is shown ground truth (A, B, C, or D) at the attack location and he reports surprise.

Mission 2: Attacks by Four Groups

Mission 2 is much like Mission 1, but now you are working in a **completely different area** with four new attacking groups (still called A▲, B⬟, C⬮, D◆).

As in Mission 1:

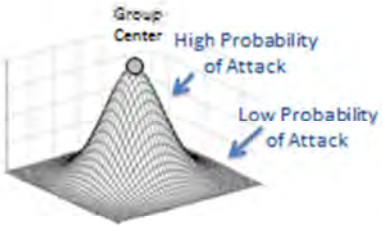
- Each group has a different operational **center** that remains constant throughout the mission. The probability of attack is highest near the center, and decreases farther from the center along a bell curve. Note: the group center will not be visible; it must be inferred from the pattern of attacks.
- One group may attack farther from its group center than another (**spread** out more).
- One group may attack more **frequently** than another.
- You should always judge based on **all** the attacks you have seen, **not just the most recent attacks**.

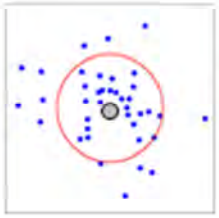
You will be asked to report probabilities on every 20th attack. You will do this 5 times as 100 attacks accumulate on the screen.

Mission 2: Continued

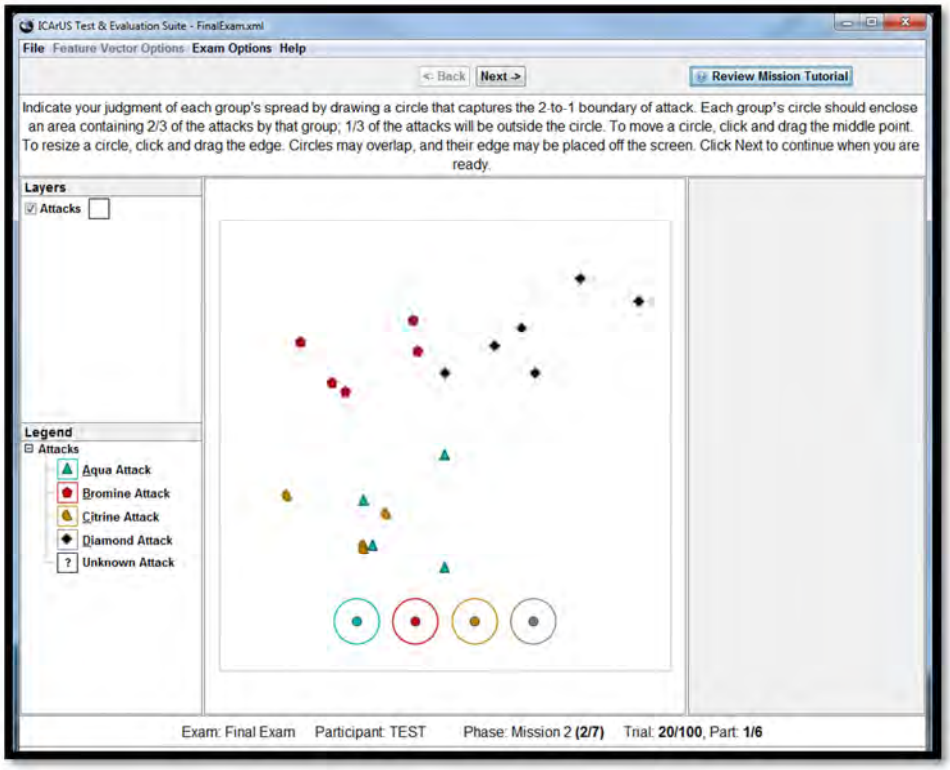
In Mission 2, in addition to reporting probabilities, you will be asked to **judge the position of each group's center and its spread**.

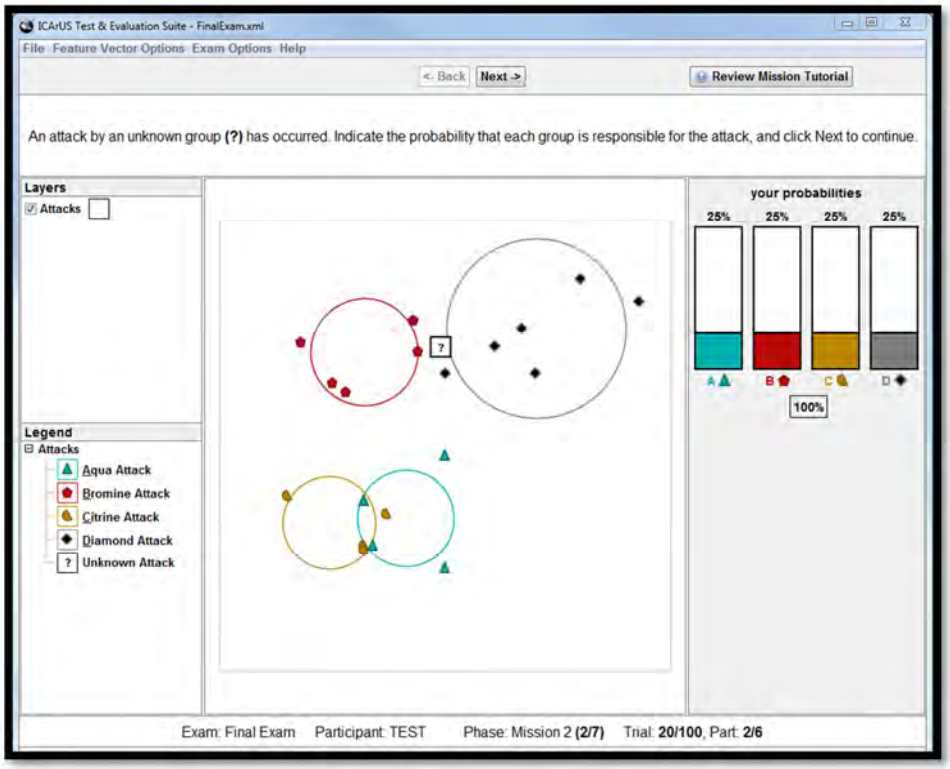
You will indicate your judgment of each groups' spread by drawing a circle that **captures the 2-to-1 boundary** of attack. This circle encloses an area containing 2/3 of the attacks; 1/3 of the attacks will be outside the circle.

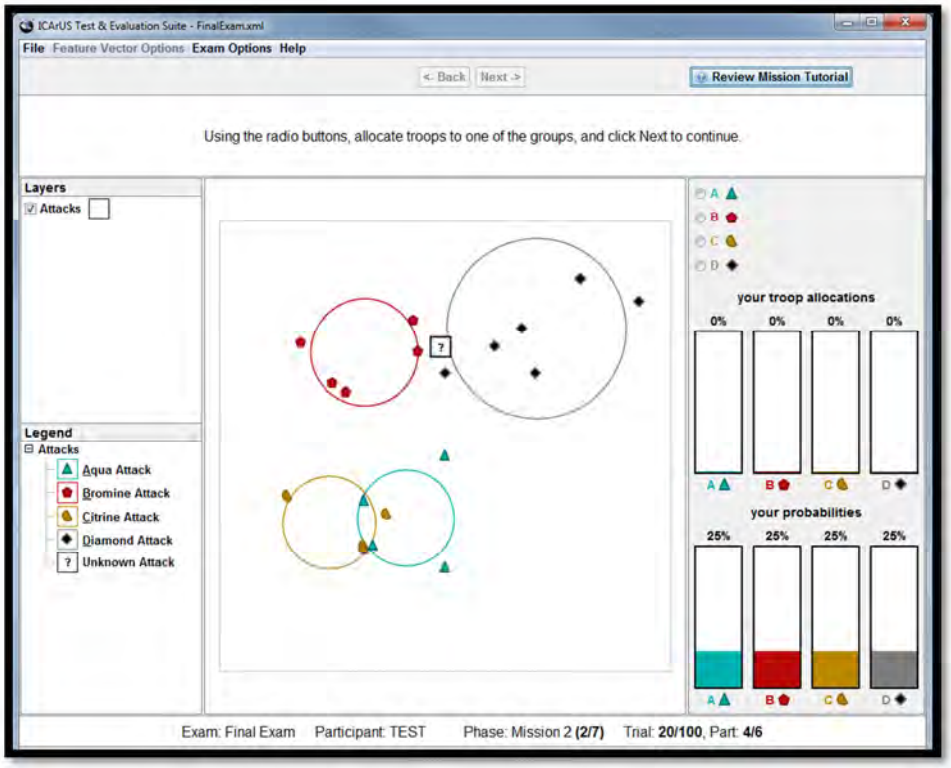


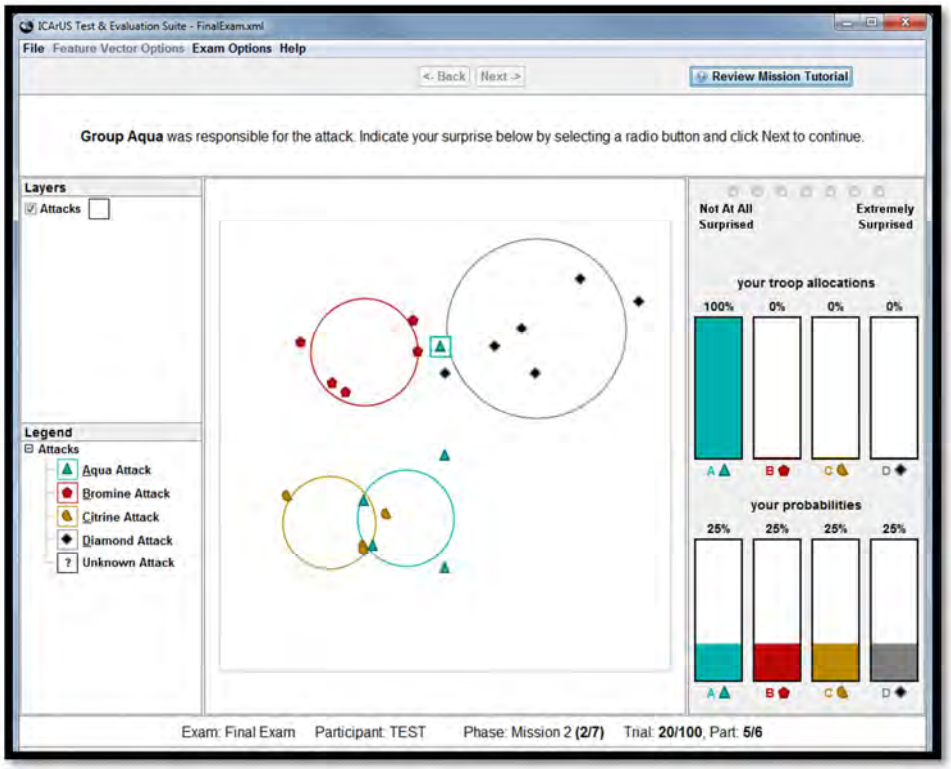


2-to-1 boundary, capturing 2/3 of the attacks


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next -> Review Mission Tutorial
Indicate your judgment of each group's spread by drawing a circle that captures the 2-to-1 boundary of attack. Each group's circle should enclose an area containing 2/3 of the attacks by that group; 1/3 of the attacks will be outside the circle. To move a circle, click and drag the middle point. To resize a circle, click and drag the edge. Circles may overlap, and their edge may be placed off the screen. Click Next to continue when you are ready.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
Exam: Final Exam Participant: TEST Phase: Mission 2 (2/7) Trial: 20/100, Part: 1/6


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next -> Review Mission Tutorial
An attack by an unknown group (?) has occurred. Indicate the probability that each group is responsible for the attack, and click Next to continue.
Layers
Attacks
your probabilities
25% 25% 25% 25%
A B C D
100%
Legend
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
Exam: Final Exam Participant: TEST Phase: Mission 2 (2/7) Trial: 20/100, Part: 2/6


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
Using the radio buttons, allocate troops to one of the groups, and click Next to continue.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
A
B
C
D
your troop allocations
0% 0% 0% 0%
your probabilities
25% 25% 25% 25%
Exam: Final Exam Participant: TEST Phase: Mission 2 (2/7) Trial: 20/100, Part: 4/6


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
Group Aqua was responsible for the attack. Indicate your surprise below by selecting a radio button and click Next to continue.
Layers
Attacks
Legend
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
Not At All Surprised
Extremely Surprised
your troop allocations
100% 0% 0% 0%
your probabilities
25% 25% 25% 25%
Exam: Final Exam Participant: TEST Phase: Mission 2 (2/7) Trial: 20/100, Part: 5/6

4 Mission 3

Finding centers. [5 blocks of 20 trials]. Unlike Task 2, the task is to find group centers along roads “as the cow walks” (rather than "as the crow flies"). After each block of trials, the subject clicks four points A, B, C, and D on the roads – each representing the “center of gravity” for a group (i.e., maximum likelihood location for a group’s center, given the group’s attacks). The subject then reports {A%, B%, C%, D%} at the attack location. After reporting the probabilities and making a forced choice in allocating resources, the subject is shown ground truth (A, B, C, or D) at the attack location and he reports surprise.

Mission 3: Attacks on Roadways

In Mission 3, you are once again working in a completely different area with four new attacking groups (still called A▲, B●, C◆, D◆).

Mission 3 is much like Mission 2, except that everything now happens on a road:

- Groups are centered along roads.
- All attacks will appear on or near roads.

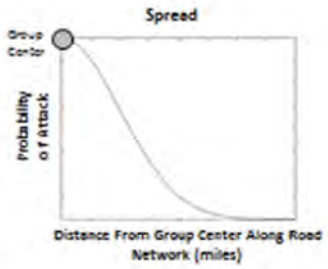
You should always judge based on all the attacks you have seen, **not just the most recent attacks**.

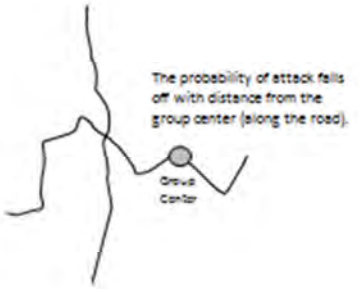
On every 20th attack, you will see the location of attack by an unknown group and be asked to report the probability of attack by each group. You will do this 5 times as 100 attacks accumulate on the screen.

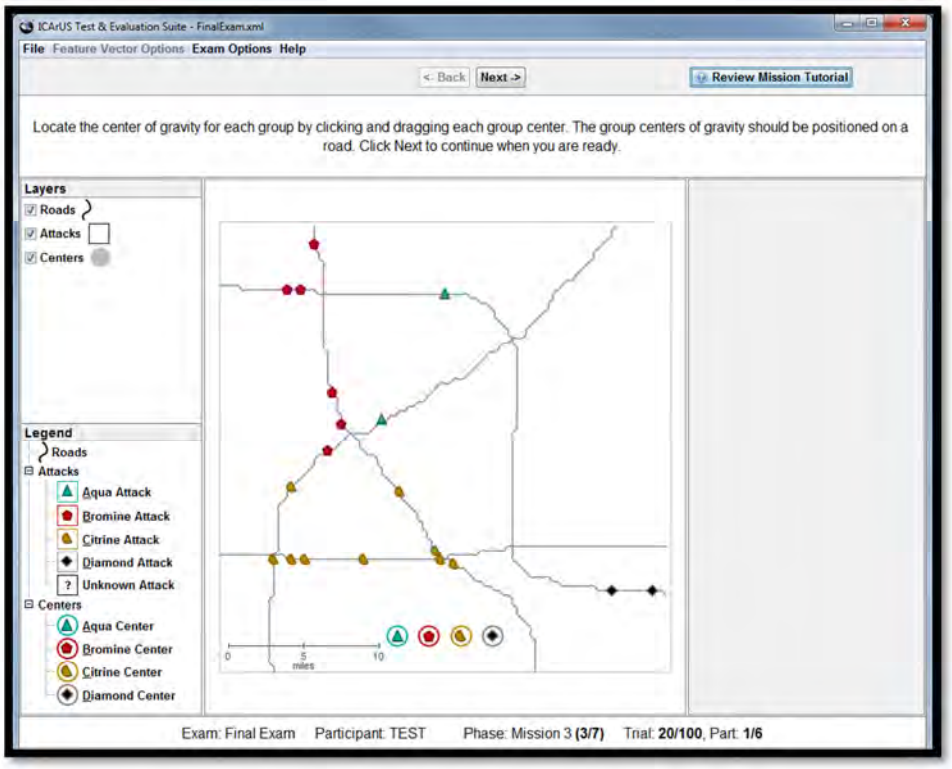
Mission 3: Distance Along Roads

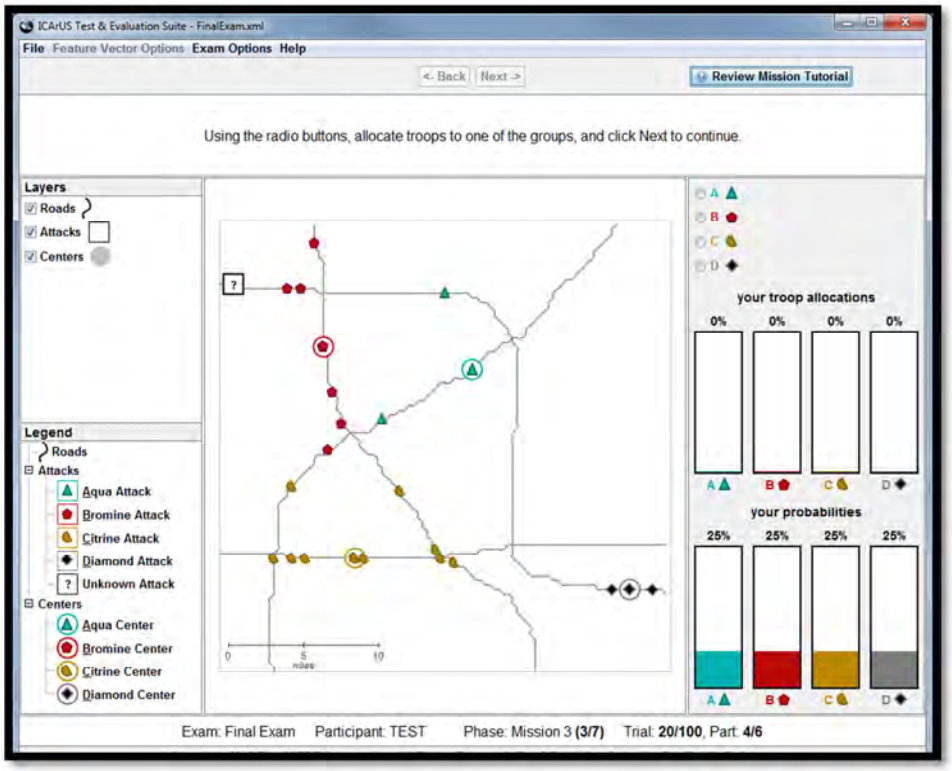
You will also be asked to indicate the center for each group. Like Missions 1 and 2, each group has a different center and attack frequency. However, here in Mission 3, **each group has the same spread (shown below):**

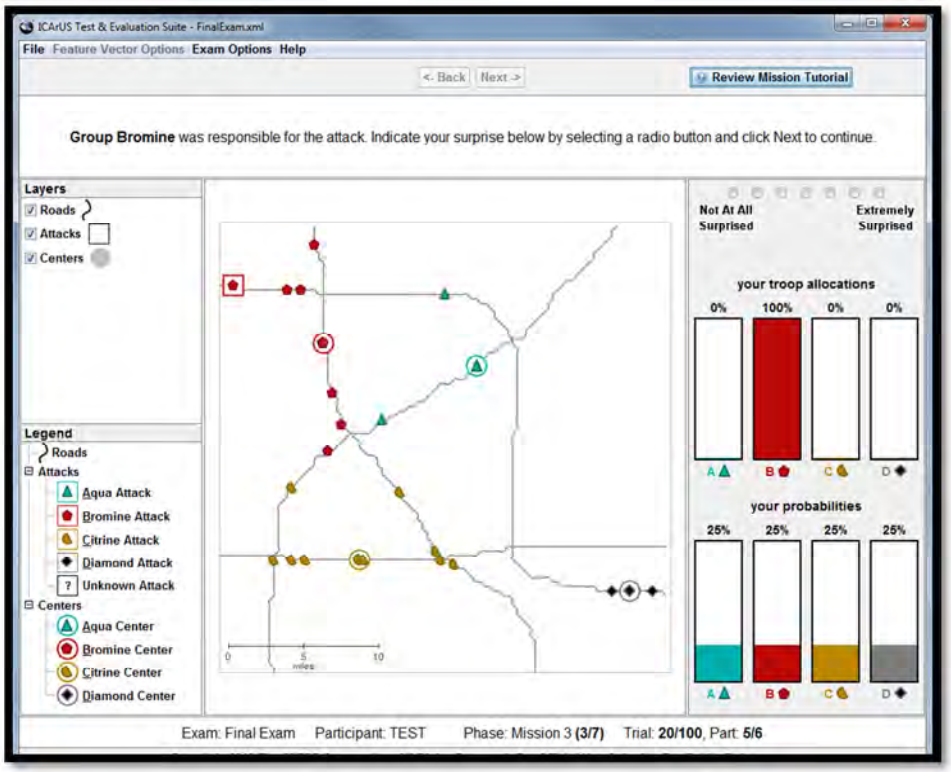
- A group's probability of attack depends on the distance from the group center, as measured along roads rather than "as the crow flies" (the shortest distance between two points).



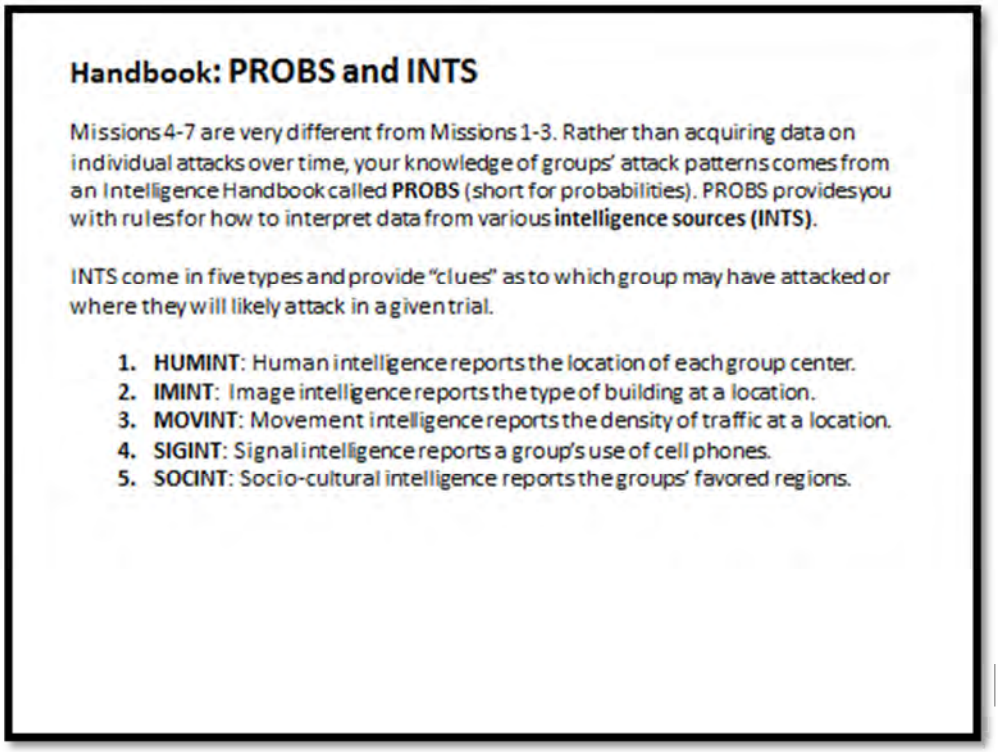



ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next -> Review Mission Tutorial
Locate the center of gravity for each group by clicking and dragging each group center. The group centers of gravity should be positioned on a road. Click Next to continue when you are ready.
Layers
Roads
Attacks
Centers
Legend
Roads
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
Centers
Aqua Center
Bromine Center
Citrine Center
Diamond Center
0 5 10 miles
Exam: Final Exam Participant: TEST Phase: Mission 3 (3/7) Trial: 20/100, Part: 1/6


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next -> Review Mission Tutorial
Using the radio buttons, allocate troops to one of the groups, and click Next to continue.
Layers
Roads
Attacks
Centers
Legend
Roads
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
Centers
Aqua Center
Bromine Center
Citrine Center
Diamond Center
0 5 10 miles
A
B
C
D
your troop allocations
0% 0% 0% 0%
your probabilities
25% 25% 25% 25%
Exam: Final Exam Participant: TEST Phase: Mission 3 (3/7) Trial: 20/100, Part: 4/6


BCArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
Group Bromine was responsible for the attack. Indicate your surprise below by selecting a radio button and click Next to continue.
Layers
Roads
Attacks
Centers
Legend
Roads
Attacks
Aqua Attack
Bromine Attack
Citrine Attack
Diamond Attack
Unknown Attack
Centers
Aqua Center
Bromine Center
Citrine Center
Diamond Center
0
5
10
miles
Not At All Surprised
Extremely Surprised
your troop allocations
0%
100%
0%
0%
A
B
C
D
your probabilities
25%
25%
25%
25%
A
B
C
D
Exam: Final Exam Participant: TEST Phase: Mission 3 (3/7) Trial: 20/100, Part: 5/6

5 Handbook



Handbook: PROBS and INTS

Missions 4-7 are very different from Missions 1-3. Rather than acquiring data on individual attacks over time, your knowledge of groups' attack patterns comes from an Intelligence Handbook called **PROBS** (short for probabilities). PROBS provides you with rules for how to interpret data from various **intelligence sources (INTS)**.

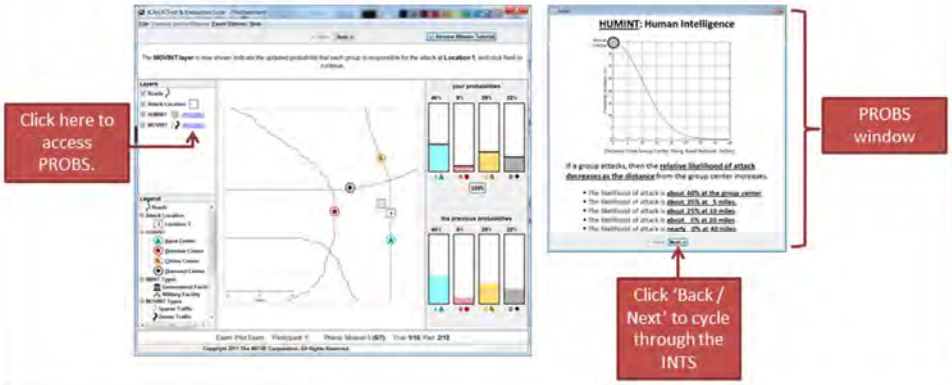
INTS come in five types and provide "clues" as to which group may have attacked or where they will likely attack in a given trial.

1. **HUMINT**: Human intelligence reports the location of each group center.
2. **IMINT**: Image intelligence reports the type of building at a location.
3. **MOVINT**: Movement intelligence reports the density of traffic at a location.
4. **SIGINT**: Signal intelligence reports a group's use of cell phones.
5. **SOCINT**: Socio-cultural intelligence reports the groups' favored regions.

Using PROBS

You should employ the PROBS Handbook throughout Missions 4-7 because you will need it to understand and make judgments from the INT data.

The PROBS will appear in a separate pop-up window whenever you receive INT data. Feel free to move the PROBS window to wherever you can see it best. You can access the PROBS Handbook at any time by clicking PROBS on the left of the screen.



Using PROBS

Click the PROBS link now to open the PROBS Handbook while you review the following pages. Then click 'Next' to continue.

Generic Constraints

There are two INTs that **apply to all groups**. These are HUMINT and SOCINT.

- For **HUMINT**, the probability of attack decreases as the attack location gets farther from a group's center (as measured along roads). It **decreases with distance** along a bell curve like in Mission 3.

- For **SOCINT**, the probability of attack by a group is larger (by a factor of 2-to-1) in **the group's own region** compared to **each other group's region**.

Specific Constraints

The PROBS for IMINT and MOVINT capture tendencies that are **specific to each group**. For example:

- For **IMINT**, groups A and B prefer (by a factor of 4-to-1) to attack near **government buildings** as opposed to **military buildings**, and vice versa for groups C and D.

- For **MOVINT**, groups A and C prefer to attack (by a factor of 4-to-1) in **dense traffic** as opposed to **sparse traffic**, and vice versa for groups B and D.

The PROBS for SIGINT are different because SIGINT will report **on only one group**.

- When **SIGINT** on a group reports cell phone activity **(chatter)**, attack by that group is more likely than each other group (by a factor of 7-to-1). When SIGINT on a group reports **silence**, attack by that group is less likely (by a factor of 1-to-3) than each other group.

INTS are Independent

IMPORTANT: The INTS you receive provide all the information you need to **perfectly judge** the probability of attack in Missions 4-7.

IMPORTANT: Each INT source provides an **independent clue** about which group conducted an attack. Specifically, the INT data you see at any time depends only on the group that attacks and is not affected by what the other INTS say.

For example, the type of traffic (MOVINT) is not affected by the type of nearby building (IMINT), so the likelihood of seeing an attack in dense traffic near a government building **depends only on the group that attacks.** It does not depend on the likelihood of seeing dense traffic given a government building.

Click Next to begin Mission 4.

6 Mission 4

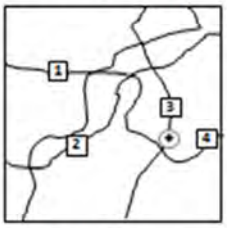
Scoping attacks. [10 trials, 2 stages per trial]. Unlike Task 3, the subject is given the center (from HUMINT) for one group, along with four possible locations 1, 2, 3, and 4 of attack by that group. In stage 1, the subject is required to estimate the probability of attack at each location based on a normal distance decay function along roads. In stage 2, the subject is given the regional boundaries for groups (SOCINT), along with the inside/outside region attack likelihoods from PROBS. The subject is required to aggregate the prior (HUMINT) and SOCINT probabilities. The subject allocates resources in percentages (not a forced choice) across the sites, and is shown ground truth (1, 2, 3, or 4). The subject reports surprise after observing ground truth.

Mission 4: One Group and Four Attack Locations

In Mission 4, the attacking group is known to be D, but the attack may come at one of four locations (1, 2, 3, or 4). Your job is to **judge the probability of attack at each location**. You will have access to two **intelligence sources (INTS)** in this mission.

Your first step is to estimate the probability of attack at each location based on data from HUMINT and the knowledge contained in your Intelligence Handbook **(PROBS)**. HUMINT illustrates the location of D's group center, and PROBS for HUMINT specifies how the **probability of attack depends on the distance (along roads) from the group center**.

Example map



HUMINT shown

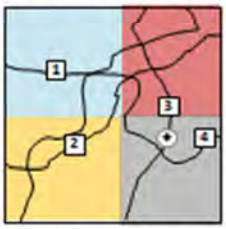
Mission 4: One Group and Four Attack Locations

After reporting probabilities, you will be given another clue in the form of SOCINT data. **The probability of attack in the group's own region is twice as high compared to attacks in another group's region.**

You will be asked **to report your surprise** upon receiving the SOCINT data. For example, after HUMINT you may think location "3" is the most likely location of attack. In that case you may be surprised if SOCINT reports that location "3" is outside group D's preferred region of attack.

Next, using SOCINT, you'll be asked to update your previous judgment (the probability of attack at each location), which was based only on HUMINT. Your updated judgment should consider **both HUMINT and SOCINT.**

Example map

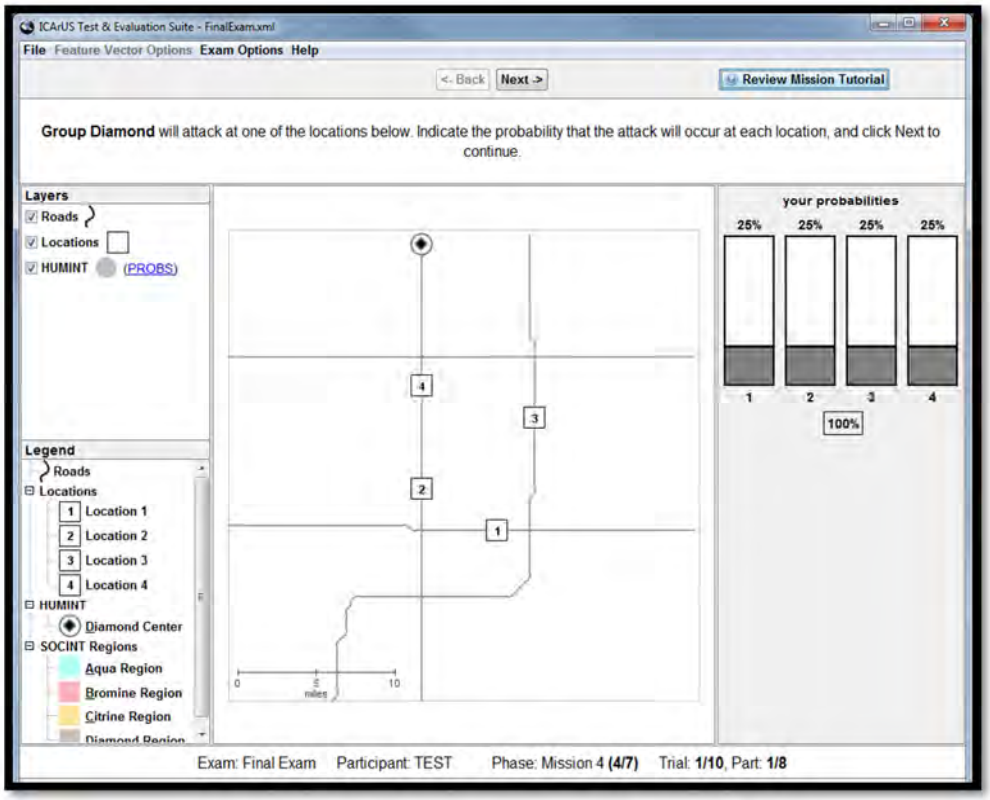


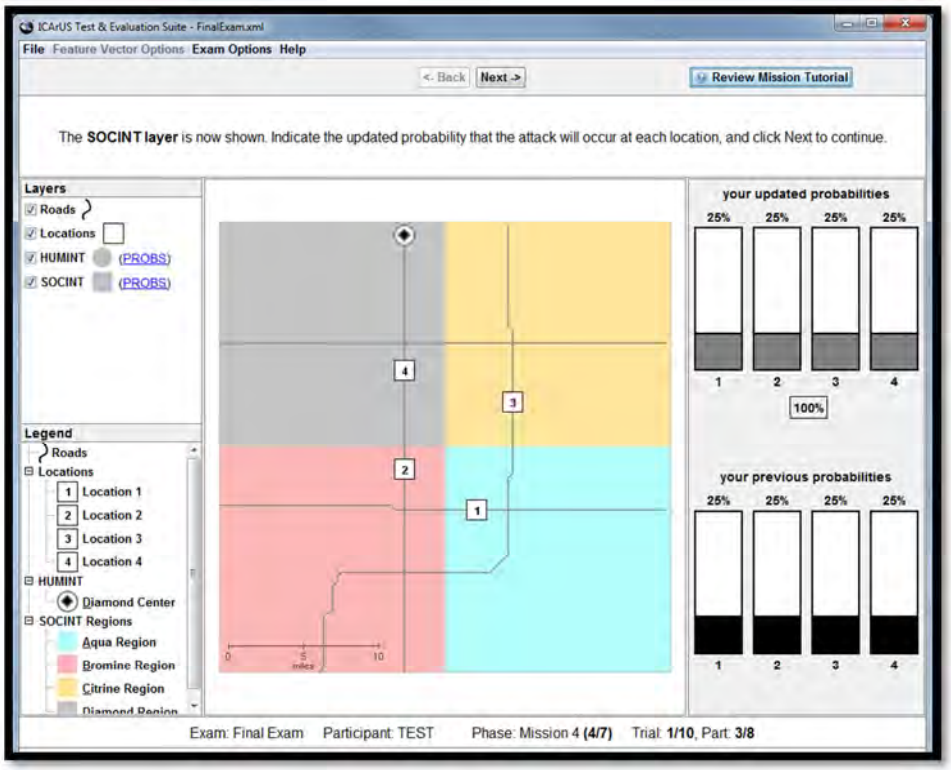
HUMINT and SOCINT shown

Mission 4: Continued

After reporting your updated probabilities, you will be asked to allocate troops in percentages. You can allocate any percentage of troops to a location, but the total troop allocation over the four locations must sum to 100%.

You will be asked to do this 10 times. Each trial is independent; that is, each attack will occur in a new area of interest, with different roads and attack locations.




ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
< Back Next ->
Review Mission Tutorial
The SOCINT layer is now shown. Indicate the updated probability that the attack will occur at each location, and click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Diamond Center
SOCINT Regions
Aqua Region
Bromine Region
Citrine Region
your updated probabilities
25% 25% 25% 25%
1 2 3 4
100%
your previous probabilities
25% 25% 25% 25%
1 2 3 4
Exam: Final Exam Participant: TEST Phase: Mission 4 (4/7) Trial: 1/10, Part: 3/8

ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
< Back Next ->
Review Mission Tutorial
Allocate troops to each location, and click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Diamond Center
SOCINT Regions
Aqua Region
Bromine Region
Citrine Region
your troop allocations
25% 25% 25% 25%
1 2 3 4
100%
your probabilities
25% 25% 25% 25%
1 2 3 4
Exam: Final Exam Participant: TEST Phase: Mission 4 (4/7) Trial: 1/10, Part: 5/8

ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back
Next ->
Review Mission Tutorial
The attack occured at Location 4. Indicate your surprise below by selecting a radio button and click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
Location 1
Location 2
Location 3
Location 4
HUMINT
Diamond Center
SOCINT Regions
Aqua Region
Bromine Region
Citrine Region
Diamond Region
Not At All Surprised
Extremely Surprised
your troop allocations
25% 25% 25% 25%
1 2 3 4
your probabilities
25% 25% 25% 25%
1 2 3 4
Exam: Final Exam Participant: TEST Phase: Mission 4 (4/7) Trial: 1/10, Part: 7/8

7 Mission 5

Fusing layers. [10 trials, 4 stages per trial]. Unlike Task 4, the subject is given an attack location (SIGACT) along with group centers (HUMINT) for four groups (A, B, C, D). The subject is also given the probabilities of attack by each group {A%, B%, C%, D%}, based on the HUMINT distance function. The subject is then given four more INTS (IMINT, MOVINT, SIGINT, SOCINT), one at a time, along with the likelihoods (from PROBS) for features of INTS. At each stage the subject updates probabilities {A%, B%, C%, D%}. After the last stage the subject allocates resources in percentages {A%, B%, C%, D%} against the groups. At the end of the trial the subject is shown ground truth and he reports surprise.

Mission 5: Four Groups and One Attack Location

In Mission 5, there will be a single attack location and four possible attacking groups (still called A▲, B●, C◆, D◆). Now **you will be given more INT data** about each attack.

HUMINT will report the locations of group centers, as in Mission 4. But in Mission 5 probabilities will be automatically computed using the HUMINT distance function. These calculations are exact.

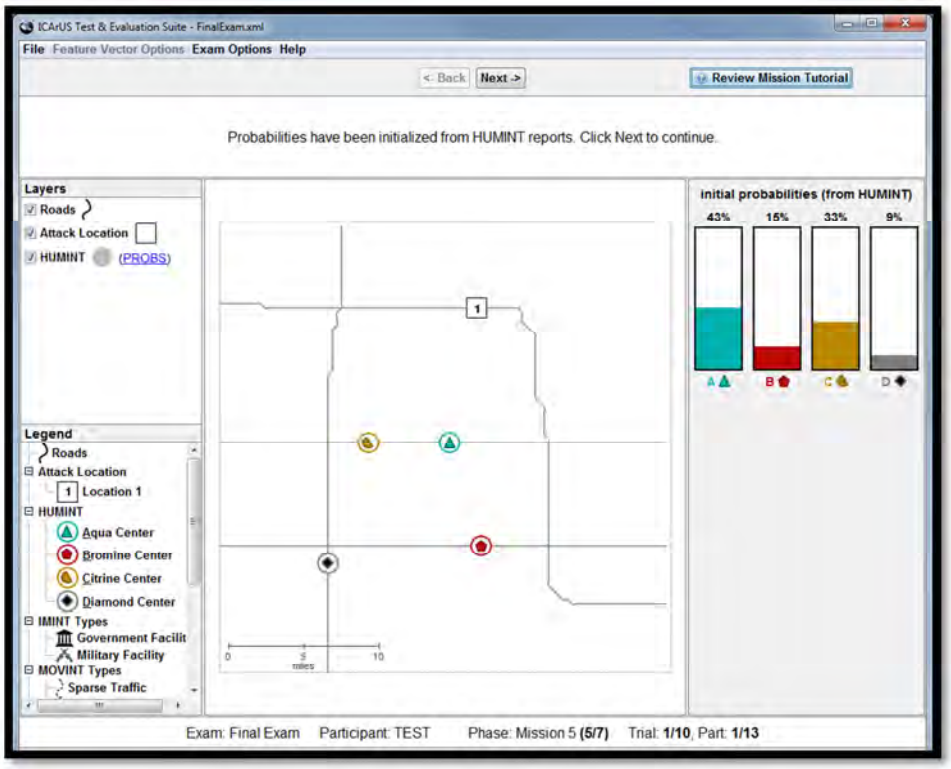
Subsequently, you will see data from four more INTS – one at a time, but in an order that will change:

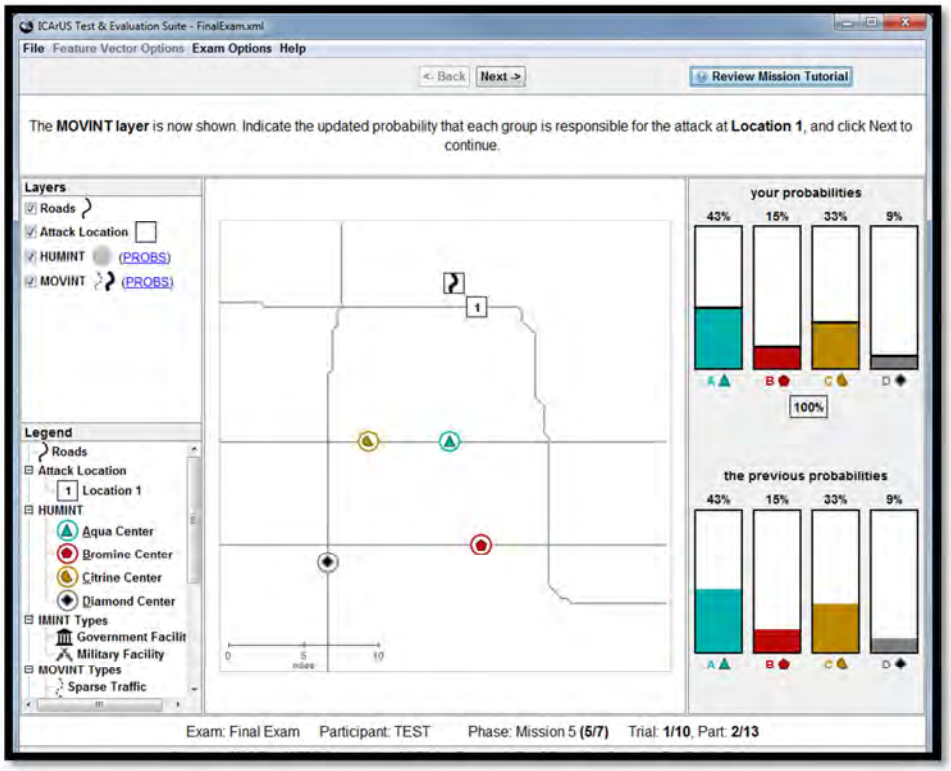
IMINT
MOVINT
SIGINT
SOCINT

Mission 5: Continued

After receiving a new INT you will be asked to revise your previous probability judgments in light of the new INT, taking into consideration the new INT *and all previous INTs*.

You will be asked to do this 10 times. Each trial is independent; that is, each attack will occur in a new area of interest, with different roads and attack locations.


BCArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
Probabilities have been initialized from HUMINT reports. Click Next to continue.
Layers
Roads
Attack Location
HUMINT (PROBS)
Legend
Roads
Attack Location
1 Location 1
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
IMINT Types
Government Facilit
Military Facility
MOVINT Types
Sparse Traffic
initial probabilities (from HUMINT)
43%
15%
33%
9%
A
B
C
D
0
5
10
miles
Exam: Final Exam Participant: TEST Phase: Mission 5 (5/7) Trial: 1/10, Part: 1/13


BCArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back Next ->
Review Mission Tutorial
The MOVINT layer is now shown. Indicate the updated probability that each group is responsible for the attack at Location 1, and click Next to continue.
Layers
Roads
Attack Location
HUMINT (PROBS)
MOVINT (PROBS)
Legend
Roads
Attack Location
1 Location 1
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
IMINT Types
Government Facilit
Military Facility
MOVINT Types
Sparse Traffic
your probabilities
43%
15%
33%
9%
A
B
C
D
100%
the previous probabilities
43%
15%
33%
9%
A
B
C
D
0
5
10
miles
Exam: Final Exam Participant: TEST Phase: Mission 5 (5/7) Trial: 1/10, Part: 2/13

8 Mission 6

Choosing layers. [10 trials, 3 stages per trial]. Much like Task 5, except the subject decides which layer of INT (IMINT, MOVINT, SIGINT, or SOCINT) to receive on each of three stages, after receiving the initial HUMINT. The criterion for each choice is to maximize the expected amount of useful information to be gained from the choice of an INT.

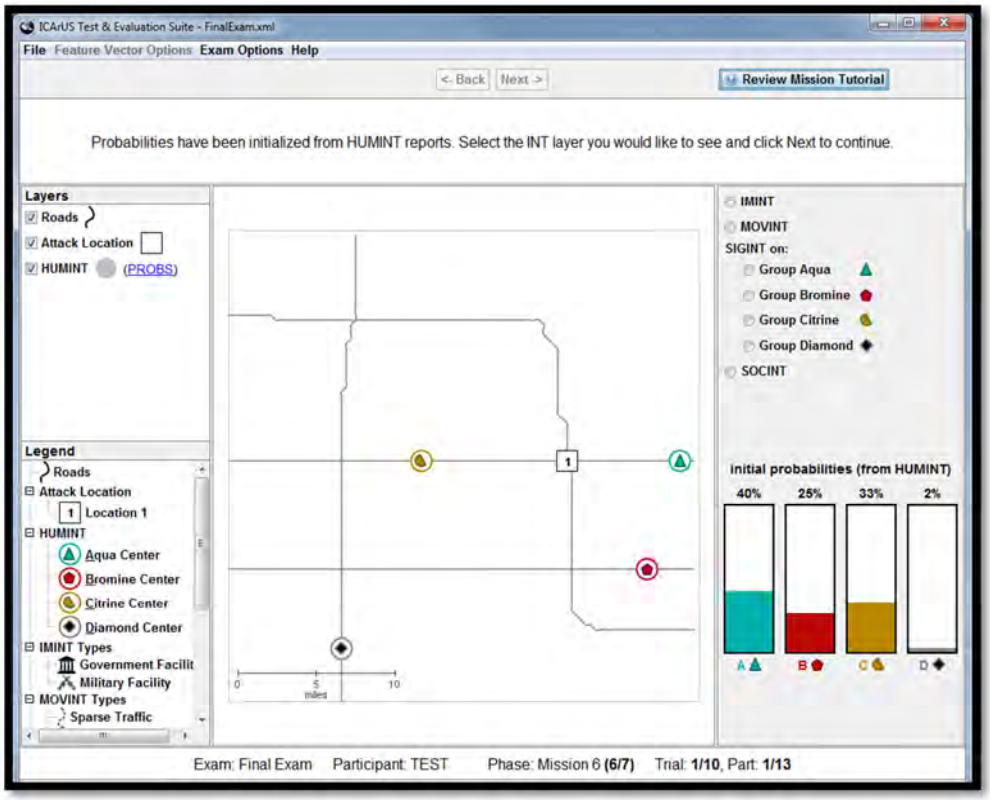
Mission 6: You Choose INTS

Mission 6 is much like Mission 5, except that after HUMINT is displayed, you will **choose any 3 of 4 INTS** from a menu, one at a time.

After you select an INT it is no longer available for selection from the menu. Remember that SIGINT is obtained on a single group of your choice. After choosing to obtain SIGINT on one group, SIGINT will no longer be available on that group or any other group.

You should choose INTS at each step to **maximize the amount of information you expect to receive** for judging attack probabilities across groups.

You will be asked to do this 10 times. Each trial is independent; that is, each attack will occur in a new area of interest, with different roads and attack locations.



9 Mission 7

Self-initiated sensemaking. [15 trials]. Task 7 is a combination, in part, of Tasks 4 and 6, but with a focus on *self-initiated* sensemaking. Participants will be given the centers of four groups (A-D) and four possible attack sites (1-4). As in Task 4, the primary task is to predict the location of attack and to allocate resources to each location {@1%, @2%, @3%, @4%}. But unlike Task 4, participants will decide *if and when* to seek additional data, as well as which data (INT) to seek. See the Phase 1 Challenge Problem Design and Test Specification document for a more detailed description of Task 7, including a summary of the major structural differences between Task 7 and Tasks 1-6.

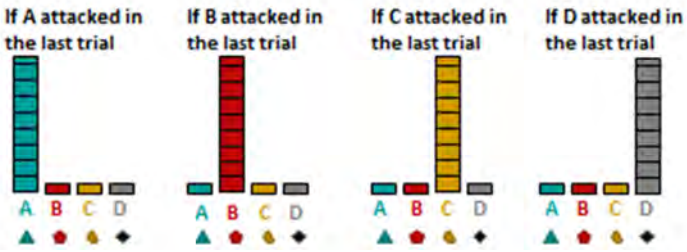
Mission 7: Groups Attack in Waves Over Time

Mission 7 differs from missions 4-6 in four ways:

1. In Mission 7, you will be working in a single area for a long period of time - **the map won't change from trial to trial**.
2. The map is more complex. Each map shows 4 groups and 4 candidate attack locations. Your task is **to report which group** is likely to attack at **which location**, and to allocate troops to counter the attack.
3. You may **use credits to purchase some INT** types.
4. You have access to new INT knowledge: **groups attack in waves** (click 'Next' to learn about this new rule).

Mission 7: Wave Rule

We have new intelligence that **groups tend to attack in waves**. **If** a group attacked in the previous trial, **then** they are **85% likely** to attack again in the current trial. This 'wave' rule is now included in your rulebook.



Mission 7: Trial Walkthrough

Step 1. At the beginning of each trial you will be asked to **report which group** is likely to attack next using the clues that the INTS provide.

You **are not required** to report the probability of attack by each group on each trial. If you **choose** to make a report, click "Update Group Judgment." If you choose not to make a report, click "Next."

Mission 7: Trial Walkthrough

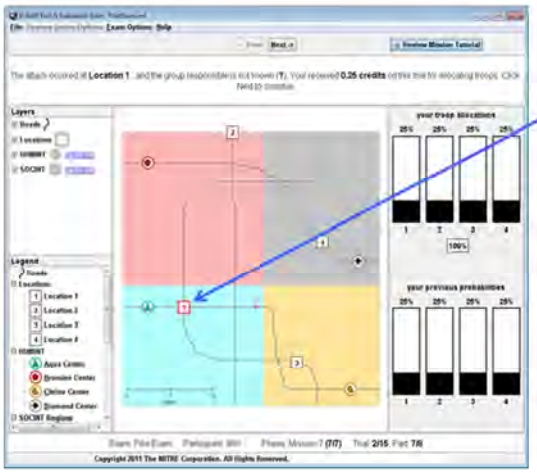
Step 2. Next, you will be asked to **report which location** is likely to be attacked.

Note: HUMINT and SOCINT are provided "for free."

Mission 7: Trial Walkthrough

Step 3. You will be asked to **allocate troops** to each location.

Mission 7: Trial Walkthrough

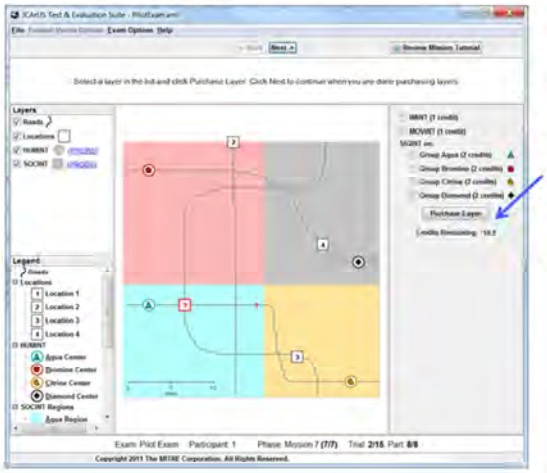


Step 4. Next, the actual **attack location will be revealed**.

If the attacker is known, it will appear inside the attack location; otherwise, a red '?' will appear, indicating the attacker was unknown.

Note: The last 5 attack locations will remain on the screen at all times.

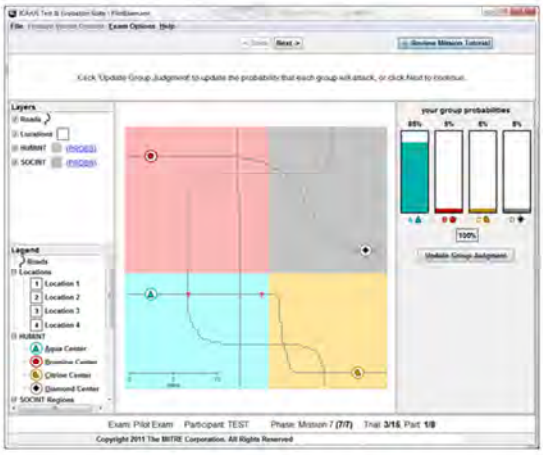
Mission 7: Trial Walkthrough



Step 5. You will **receive credits** based on how effectively you allocated troops.

You can use credits to **purchase additional intelligence** when prompted. Intelligence can be used to get ***back on track*** if you incorrectly predicted the attacker or attack location.

Mission 7: Trial Walkthrough



After viewing the intelligence you purchased, you'll be asked to update the probability of attack by each group, and a new trial will start.

Mission 7 will last for 15 trials.

Mission 7: Notes about Credits

You have a limited number of credits to spend, so use them wisely. You will start the mission with 10 credits.

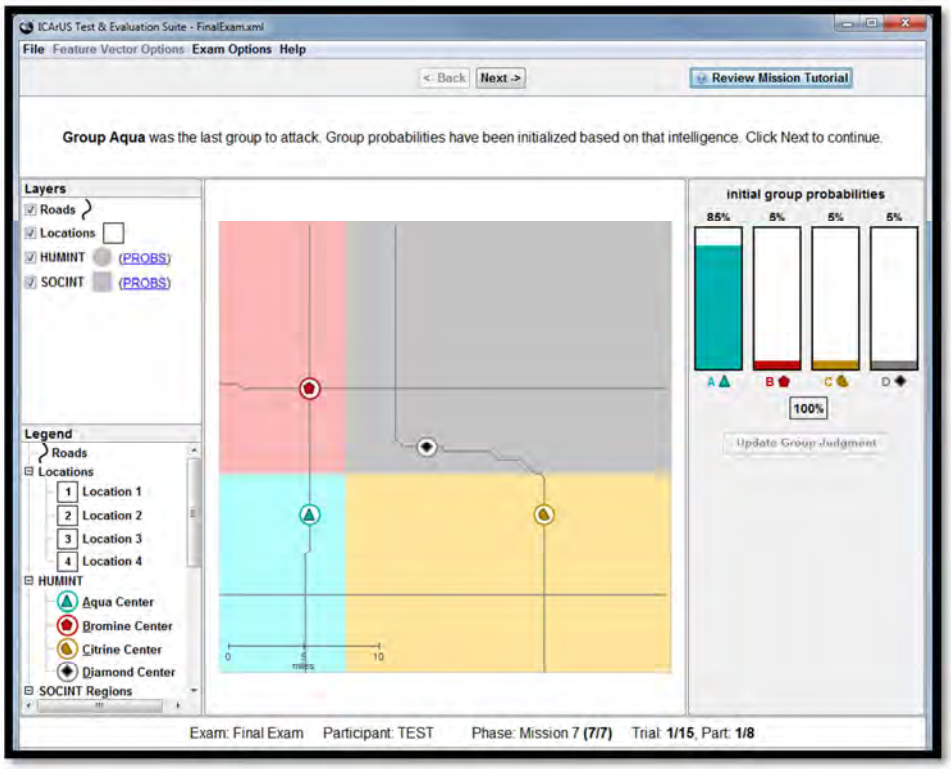
You may purchase as many layers as you have credits for. Each layer costs 1-2 credits.

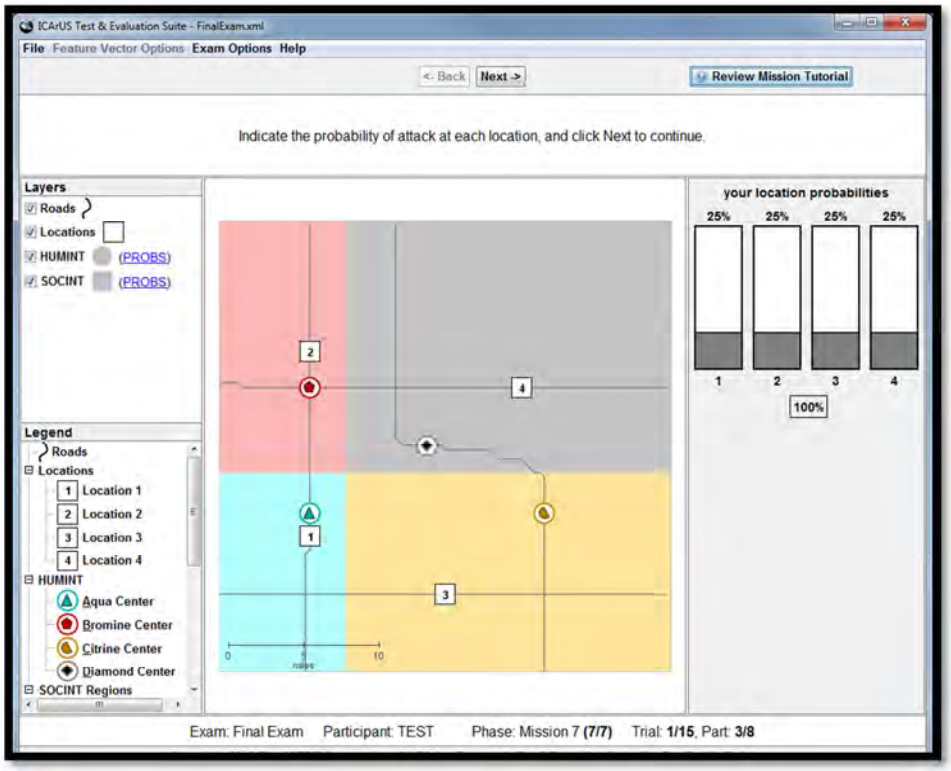
All credits expire at the end of the mission. You will not receive a higher score if you have credits remaining.

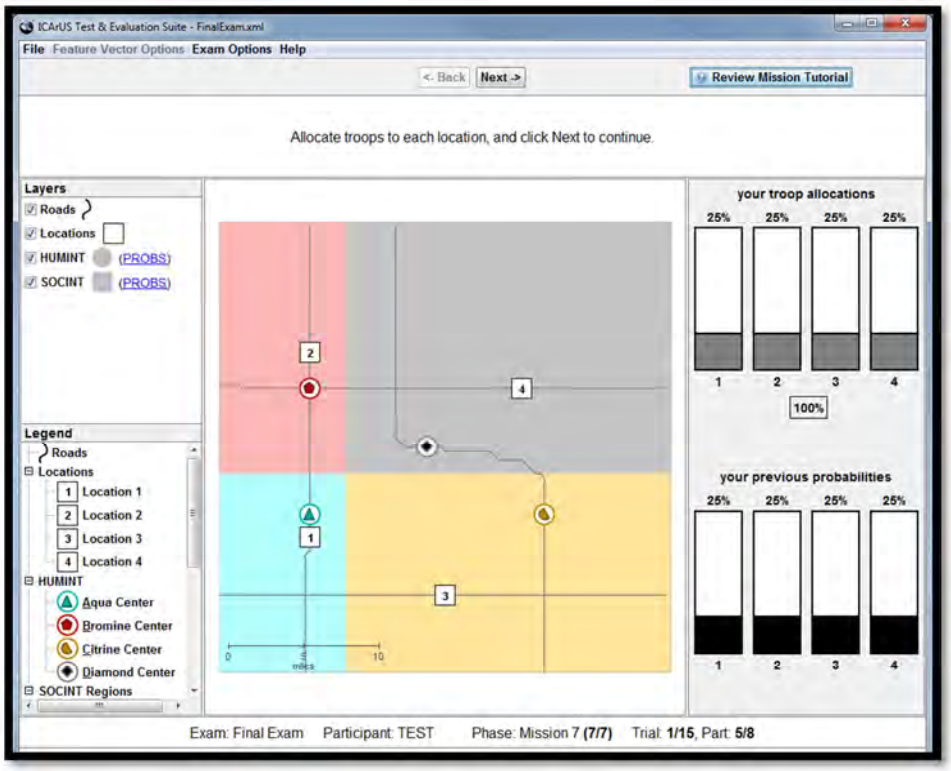
Mission 7: Beginning and Ending

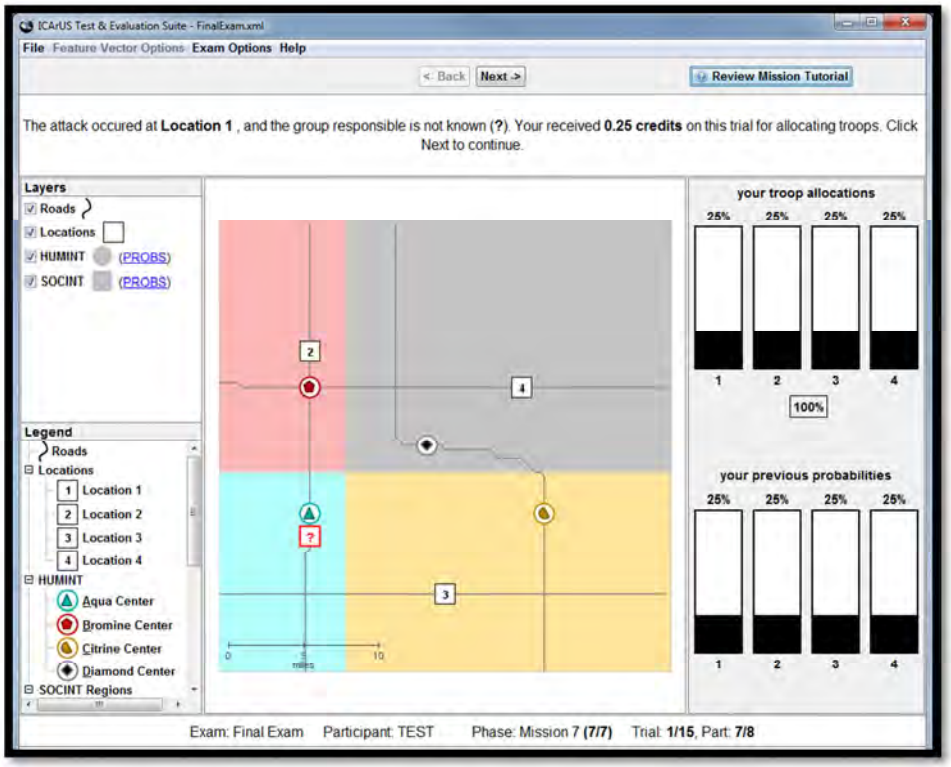
On trial 1, you will start in the middle of an attack wave. At step 1 of the trial, **you will be told which group attacked just before** you were assigned to the mission, and the probabilities will automatically pre-populate according to the new wave rule.

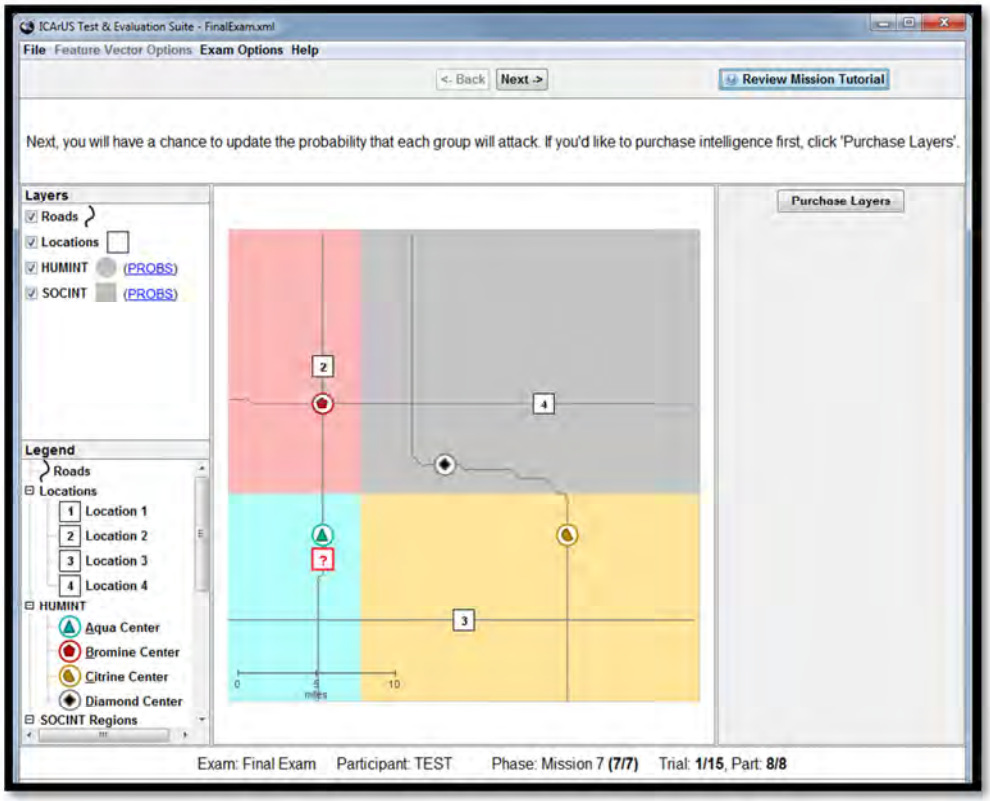
You can click 'Review Mission Tutorial' at the top of the GUI window to review this tutorial at any time during the mission.


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
< Back Next ->
Review Mission Tutorial
Group Aqua was the last group to attack. Group probabilities have been initialized based on that intelligence. Click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
SOCINT Regions
initial group probabilities
85% 5% 5% 5%
A B C D
100%
Update Group Judgment
Exam: Final Exam Participant: TEST Phase: Mission 7 (7/7) Trial: 1/15, Part: 1/8


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
< Back Next ->
Review Mission Tutorial
Indicate the probability of attack at each location, and click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
SOCINT Regions
your location probabilities
25% 25% 25% 25%
1 2 3 4
100%
Exam: Final Exam Participant: TEST Phase: Mission 7 (7/7) Trial: 1/15, Part: 3/8

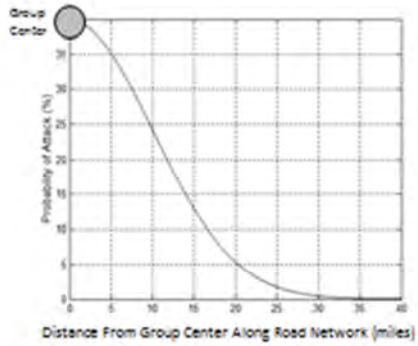

ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
< Back Next ->
Review Mission Tutorial
Allocate troops to each location, and click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
SOCINT Regions
your troop allocations
25% 25% 25% 25%
1 2 3 4
100%
your previous probabilities
25% 25% 25% 25%
1 2 3 4
Exam: Final Exam Participant: TEST Phase: Mission 7 (7/7) Trial: 1/15, Part: 5/8


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
< Back Next ->
Review Mission Tutorial
The attack occured at Location 1 , and the group responsible is not known (?). Your received 0.25 credits on this trial for allocating troops. Click Next to continue.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
SOCINT Regions
your troop allocations
25% 25% 25% 25%
1 2 3 4
100%
your previous probabilities
25% 25% 25% 25%
1 2 3 4
Exam: Final Exam Participant: TEST Phase: Mission 7 (7/7) Trial: 1/15, Part: 7/8


ICArUS Test & Evaluation Suite - FinalExam.xml
File Feature Vector Options Exam Options Help
<- Back
Next ->
Review Mission Tutorial
Next, you will have a chance to update the probability that each group will attack. If you'd like to purchase intelligence first, click 'Purchase Layers'.
Layers
Roads
Locations
HUMINT (PROBS)
SOCINT (PROBS)
Purchase Layers
Legend
Roads
Locations
1 Location 1
2 Location 2
3 Location 3
4 Location 4
HUMINT
Aqua Center
Bromine Center
Citrine Center
Diamond Center
SOCINT Regions
2
4
?
3
0
5
10
miles
Exam: Final Exam Participant: TEST Phase: Mission 7 (7/7) Trial: 1/15, Part: 8/8

10 Appendix A: PROBS

HUMINT: Human Intelligence



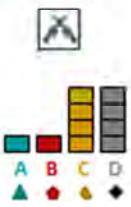
If a group attacks, then the **relative likelihood of attack decreases as the distance** from the group center increases.

- The likelihood of attack is **about 40% at the group center**.
- The likelihood of attack is **about 35% at 5 miles.**
- The likelihood of attack is **about 25% at 10 miles**.
- The likelihood of attack is **about 5% at 20 miles**.
- The likelihood of attack is **nearly 0% at 40 miles**.

IMINT: Image Intelligence

If the attack is near a **government** building, then attack by A or B is **4 times as likely** as attack by C or D.

If the attack is near a **military** building, then attack by C or D is **4 times as likely** as attack by A or B.



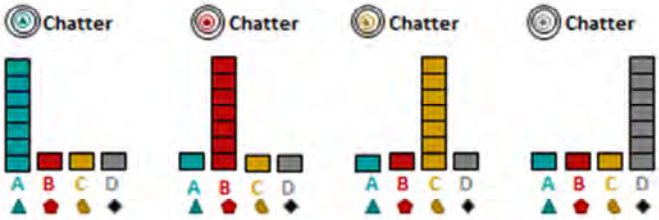
MOVINT: Movement Intelligence

If the attack is in **dense** traffic, then attack by A or C is **4 times as likely** as attack by B or D.

If the attack is in **sparse** traffic, then attack by B or D is **4 times as likely** as attack by A or C.

SIGINT: SIGNAL Intelligence

If SIGINT on a group reports **chatter**, then attack by that group is **7 times as likely** as attack by each other group.



If SIGINT on a group reports **silence**, then attack by that group is **1/3 as likely** as attack by each other group.

SOCINT: Socio-Cultural Intelligence

If the attack is in a group's region, then attack by that group is 2 times as likely as attack by each other group.

"Wave" Rule

If a group attacked in the previous trial, then they are 85% likely to attack again in the current trial.